Capacitive Vector Skin Friction Measurement Systems for Complex Flow Fields, Phase I

Completed Technology Project (2018 - 2019)

Project Introduction

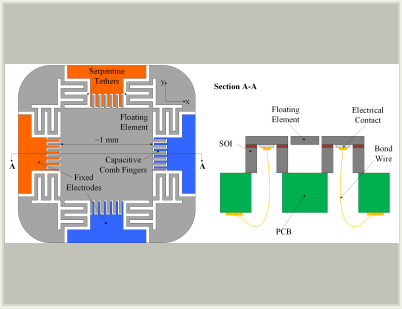
The Interdisciplinary Consulting Corporation (IC^2) proposes to develop dual-axis shear stress sensors that are applicable in ground test facilities covering a large range of flow speeds in response to NASA SBIR 2018 Phase I solicitation subtopic *A1.08: Aeronautics Ground Test and Measurements Technologies*. The proposed sensing system addresses a critically unmet measurement need in NASA's technology portfolio, specifically the ability to make time-resolved, continuous, direct, two-dimensional measurements of mean and fluctuating wall shear stress in wall-bounded turbulent and transitional flows in subsonic and transonic facilities. The realization of this capability not only benefits advanced air vehicle development but also impacts fundamental compressible boundary layer physics research areas such as transition to turbulence in three-dimensional flows, extending the current capabilities of NASA's ground test facilities.

The proposed innovation is a dual-axis, instrumentation-grade, robust, high-bandwidth, high-resolution, silicon micromachined differential capacitive shear stress sensor for subsonic and transonic applications. The sensor system will enable localized, **non-intrusive, vector measurement of mean and fluctuating wall shear stress** for characterization of complex boundary-layer flows in ground-test facilities. The differential capacitive measurement scheme offers high sensitivity to in-plane shear stress as well as common-mode rejection of pressure fluctuations. Two sets of differential capacitors provide shear stress measurement capability in two orthogonal directions to provide the wall shear stress vector. Backside electrical contacts using IC^2's patent-pending fabrication and packaging process enable the sensor to remain flush with the test article surface while significantly reducing fabrication complexity and cost. The modeling aspects of the proposed design approach facilitate design optimization for various applications and flow conditions.

Anticipated Benefits

The proposed technology enables dual-axis wall shear stress measurement in a wide range of subsonic to transonic test facilities including: NASA Langley Research Center's 14' by 22' Subsonic Wind Tunnel, Basic Aerodynamics Research Tunnel (BART), and 16' Transonic Dynamic Tunnel; the 9' x 15' Low-Speed Wind Tunnel at NASA Glenn Research Center; and the 11' x 11' Transonic Unitary Plan Wind Tunnel at NASA Ames Research Center.

Customers seeking or currently designing next-generation civilian or defense aircraft have a similar measurement need. Furthermore, active flow control (a rapidly growing area of research and development) requires compact, accurate measurements of key fluid dynamic parameters such as wall shear stress. Non-NASA applications include:



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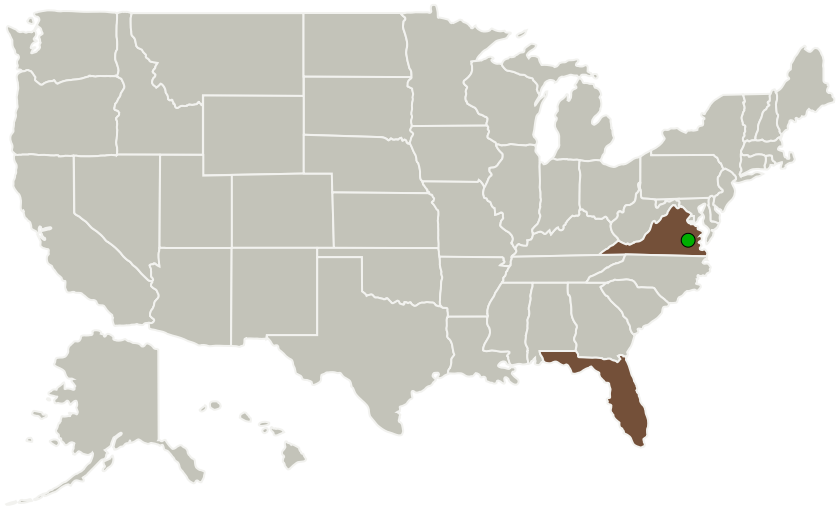
- Other government agencies such as Army and Air Force
- University wind tunnels
- Industry aircraft and automotive manufacturers such as Boeing, Airbus, GM, and Ford

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Interdisciplinary Consulting Corporation	Lead Organization	Industry	Gainesville, Florida
Langley Research Center(LaRC)	Supporting Organization	NASA Center	Hampton, Virginia

Primary U.S. Work Locations	
Florida	Virginia

Project Transitions

July 2018: Project Start

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Interdisciplinary Consulting Corporation

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

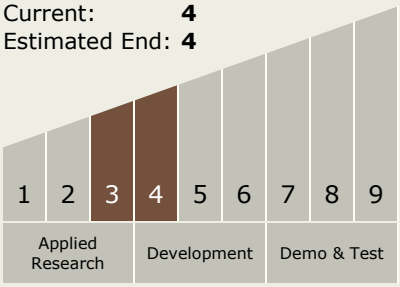
Carlos Torrez

Principal Investigator:

David Mills

Technology Maturity (TRL)

Start: **3**
Current: **4**
Estimated End: **4**



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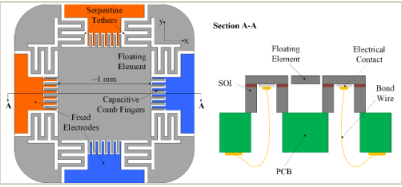
February 2019: Closed out

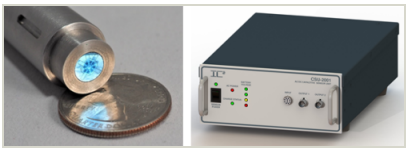
Closeout Documentation:

- Final Summary Chart*(https://techport.nasa.gov/file/140958)*

Images



Briefing Chart Image
Capacitive Vector Skin Friction Measurement Systems for Complex Flow Fields, Phase I *(https://techport.nasa.gov/image/126915)*



Final Summary Chart Image
Capacitive Vector Skin Friction Measurement Systems for Complex Flow Fields, Phase I *(https://techport.nasa.gov/image/125970)*

Technology Areas

Primary:

- TX15 Flight Vehicle Systems
  - TX15.1 Aerosciences
    - TX15.1.1 Aerodynamics

Target Destination

Earth